Smart Helmet

Group 22

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Introduction
Motivation

- In 2014, 92,000 motorcyclists were injured and 4,586 died in motorcycle-related crashes in the United States
  - U.S. Department of Transportation’s National Highway Traffic Safety Administration (NHTSA)
- Motorcycle technology is uncommon in the market
  - Most options are unrealistically expensive
- 86% of bikers are concerned with safety and actively wear a helmet
- Take a proactive approach to safety on the road
Similar Projects

Skully AR-1

- Bluetooth connectivity to smart phone
- Internet connectivity via smart phone
- Open SDK
- $11 million in funding and backed by Intel
- Over 3,000 preorders
- FAILED: Declared bankruptcy due to poor product and financial management

BikeHUD

- Modular Design
- Displays 3 pieces of information at a time
- Motorcycle Data, GPS, Audio, Rear Vision, Proximity Safety Alerts
- Released in 2014 for under $500
- Only successful Bike HUD so far

NUVIZ Ride:HUD

- Bluetooth connectivity to smart phone
- Internet connectivity via smart phone
- LCOS display
- GPS navigation, Helmet Cam, Telemetry Data, Phone Calls, Music
- $200k in crowdfunding
- FAILED: Too complex to fabricate

BMW Motorrad Vision HUD

- Features integrated speakers, glass display, diagnostic information, wirelessly controlled menus
- Allows rider to see behind them
- Early stages of development
- Showcased at CES 2016
Goals:

- Reduce accidents
  - The Smart Helmet can improve road safety
  - Dangers on the road are an ever-growing concern
  - Save lives
- Increase knowledge of hardware production
  - Process of turning an idea to a product
  - Learn PCB printing process
- Offer better options for motorcycle safety
  - Cheaper
  - Compatible with all bikes
  - Small and unobtrusive
Objectives

- Create a cheaper option for motorcycle safety
  - Competitive price compared to other expensive options
- Smart Helmet will be equipped with a Heads-Up Display (HUD)
  - Visual Proximity Warning
  - Lightweight
  - Wireless
  - Prolonged Battery Life from Solar Panels
  - Does not interfere with driving
- Reliable system
  - High accuracy
  - Minimal design
  - Exchangeable parts
Requirement Specifications

Functional Requirements

- **Two modules with separate functions**
  - Bike Proximity Sensor Module and Helmet HUD Module

- **Information to rider**
  - Able to detect surrounding automobiles in close range (20ft) to the rider
  - Interface with the rider's turn signal inputs to read the driver's intentions
  - Ranging data to a visual display that the user can easily see

- **Power**
  - The proximity sensor module shall draw power from the motorcycle
  - The helmet system shall draw power from a rechargeable battery
    - The helmet system shall utilize solar energy for extended energy usage
Requirement Specifications

Rear-Mounted Module Hardware Requirements:

- Mounted onto the rear of the motorcycle
- Detect driver's use of the turn signal
- Interface with the proximity sensors
  - Contain proximity sensors in a daisy-chain series
  - Detect an automobile within 20 feet of the motorcycle
- Wirelessly communicate with the helmet module
- Draws power from the motorcycle

Rear-Mounted Module Software Requirements:

- Include functions to activate proximity sensors and receive ranging data
- Consolidate ranging data from all sensors for accurate distance reading
- Implement processes to send data over wireless communication
- Convert ranging data into the appropriate units of measurement
 Requirement Specifications

Helmet Module Hardware Requirements

- Mounted onto the rider’s helmet
- Wireless communication to receive data from the rear-mounted module
- Visual display to show vital information to the rider
- Audio speaker that will alert the rider of potentially dangerous situations
- Enclosed in order to prevent damage from environmental conditions
- Powered via solar charging and rechargeable battery

Helmet Module Software Requirements

- Implement functions to control the visual display to show proximity data
- Use methodologies for receiving wireless data
- Consolidate ranging data to provide an accurate reading
- Display a symbolic representation of the distance to the visual display
Video Demonstration
Challenges and Restrictions

**Time Scheduling**
Difficult to find available times for four full-time students. Only so many times we can meet up as a group realistically.

**Older Bike**
The motorcycle used is completely analog and therefore does not contain any digital outputs or on-board diagnostics.

**Sensor Selection**
Due to limited budget, the Smart Helmet team must work with lower ranged sensors and chain them together in sets to fulfill the range requirements.

**Transparent Display**
The uTOLED-20-G2 transparent display no longer sold by 4D Systems due to “the manufacturer of the TOLED display glass discontinuing supply due to quality issues.”
Overall System Block diagram

Motorcycle Battery

12V

Motorcycle Battery

5V

Motorcycle Battery

Power Regulator

5V

Proximity & Diagnostic Processor

Wireless Transmitter

Proximity Sensors

Bike Diagnostics Interface

Wireless Receiver

USB Port

5V

Rechargeable Battery

5V

Solar Panels

Wired Charging

Graphics/Audio Processor

Heads Up Display (HUD)

Alert Speaker

Bike Mounted Module

Helmet Mounted Module

Microcontrollers

Power

Peripherals
Bike Module - System Overview
Bike Module - PCB
Bike Module - Power Block Diagram

Motorcycle Battery

12V

Power Regulator

5V

Proximity & Diagnostic Processor

Wireless Transmitter

Proximity Sensors

Bike Diagnostics Interface

Bike Mounted Module

- Microcontrollers
- Power
- Peripherals
Bike Module - Power

- Front Module and Proximity Sensors Powered by Existing Bike Battery
  - Voltage regulator will ensure each module receives power needed without over-voltage
## Bike Module - Microcontroller Selection

<table>
<thead>
<tr>
<th></th>
<th>I/O Pin Ports</th>
<th>Architecture</th>
<th>Processor Speed</th>
<th>Price</th>
</tr>
</thead>
<tbody>
<tr>
<td>Raspberry Pi 3</td>
<td>26</td>
<td>64/32-bit ARM</td>
<td>1.2 GHz</td>
<td>$40</td>
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<tr>
<td>MSP430</td>
<td>32</td>
<td>16-bit ARM</td>
<td>16 MHz</td>
<td>$20</td>
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<tr>
<td>Arduino Uno</td>
<td>26</td>
<td>8-bit AVR RISC</td>
<td>20 MHz</td>
<td>$10</td>
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</tbody>
</table>
Bike Module - Microcontroller Specifications

Why we chose the Arduino Uno MCU:
- Removable processing chip
- Sufficient processing power
- Low power consumption
- Relatively low cost
- Easy to mount on PCB

<table>
<thead>
<tr>
<th>Part No.</th>
<th>EL-CB-001</th>
</tr>
</thead>
<tbody>
<tr>
<td>Name</td>
<td>Atmega 328</td>
</tr>
<tr>
<td>Processor Speed</td>
<td>20 MHz</td>
</tr>
<tr>
<td>Operating Cores</td>
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</tr>
<tr>
<td>Storage ROM</td>
<td>32 KB</td>
</tr>
<tr>
<td>SRAM</td>
<td>2 KB</td>
</tr>
<tr>
<td>I/O lines</td>
<td>26</td>
</tr>
</tbody>
</table>
Bike Module - Peripherals Block Diagram

Motorcycle Battery
   12V
   \->
Power Regulator
   5V
   \->
Proximity & Diagnostic Processor
   \->
Wireless Transmitter
   
Proximity Sensors
Bike Diagnostics Interface

Bike Mounted Module

- Microcontrollers
- Power
- Peripherals
Bike Module - Proximity Sensor Options

Proximity sensors will be mounted on the rear end of the motorcycle to detect vehicles in the driver's blindspot. The available options for proximity sensors came down to sonar, LIDAR, and infrared. Each type of sensor had its respective pros and cons.

<table>
<thead>
<tr>
<th>Sensor Types Specification Summary</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Model</strong></td>
</tr>
<tr>
<td>Sonar</td>
</tr>
<tr>
<td>LIDAR</td>
</tr>
<tr>
<td>Infrared</td>
</tr>
</tbody>
</table>
Why we chose the LV-MaxSonar -EZ1 sonar sensor:

- Relatively low cost
- Fulfills distance requirement
- Chaining capabilities
- Functions at driving speeds
- Allows for easy configurations
Bike Module - Proximity Sensor Connection

- Multiple MaxSonar sensors will be hardwired together to cover the entirety of a biker's blindspot.
  - All of the sensors are wired directly to ground, power, and an input port on the MCU mounted onto the bike
  - Each of the sensors are chained together using the TX and RX pins on the proximity sensors
    - The sensors will record readings in a cascading order, one after another, until the signal is cut

![Diagram of bike module with proximity sensors and connection instructions]
Bike Module - Proximity Sensor Software Logic
Bike Module - Signal Interface

- Interface with motorcycle will be completely analog
  - The bike we are using is an antique
  - Allows the project to work on any model of motorcycle
- Information is 'read' by measuring voltage on turn signal dash wires
  - Left turn signal
  - Right turn signal
  - Additional information available:
    - Change oil notification
    - Engine power
- Hopeful stretch goals
  - Read analog engine RPM
  - Read analog motorcycle speed
Bike Module - Signal Interface
Bike Module - Wireless

- Using Bluetooth Low-Energy HM-10 Module
  - Communication via UART serial
  - Can be pre-programmed
    - Mode/settings
    - Endpoint
  - Broadcast range is far which allows flexibility

- Set to Master in the Master-Slave relationship
  - Broadcast only (not required)
  - Hosts the connection
    - More energy use compared to Helmet
    - Not limited by battery power
Helmet Module - System Overview

Breakout Pins

1. IN4148D035-7
   - GND
   - RAW
   - Voltage Regulator

2. IC4 7805TV
   - GND

3. 1µF

4. MCU
   - TX0
   - RX0
   - VCC
   - GND

5. WIRELESS_RX

6. WIRELESS_TX

7. A0

8. A1

9. A2

10. A3

11. A4

12. A5

13. A6

14. A7

15. A8

16. A9

17. A10

18. SCR_1_SCL

19. SCR_1_SDA

20. RAW

21. MCU VCC

22. GND

23. SPI

24. Battery Charging Power

25. Spare Analog IO

26. Screen 1 IO

27. Screen 2 IO

28. Screen 3 IO

29. MCU Serial

30. Breakout Pins

31. Arduino Pro Mini
Helmet Module - PCB
Helmet Module - Peripherals Block Diagram

- **Wired Charging**
  - **USB Port** connected to **Rechargeable Battery**
  - **Solar Panels** connected to **Rechargeable Battery**

- **Wireless Receiver** connected to **Graphics/Audio Processor**

- **Graphics/Audio Processor** connected to **Heads Up Display (HUD)** and **Alert Speaker**

- **Helmet Mounted Module**

Legend:
- Red: Microcontrollers
- Orange: Power
- Green: Peripherals
Helmet Module - Peripherals: Display Selection

- Two displays will be mounted onto the outside of the helmet. They will be mounted below the visor one on each side to notify the biker of possible dangers on either blind spot
- LED Strip vs OLED Non-Transparent Screen
  - Power consumption, price, visibility, versatility, and usability are all factors that went into choosing the display type
  - Red LED Strip - $5.99
  - 128x64 OLED LCD LED white display by DIYmall - $9.99
- The OLED was chosen since it provides the Smart Helmet team with more customization options. This allows us to provide the users with more information while still adhering to usability standards
Helmet Module - Display Software
Helmet Module - Software Display Example

- The current display design is using a five symbol rating system to signify how close a vehicle is to the biker’s blind spot. When the oncoming vehicle reaches a dangerous level, five arrows will appear (based on which turning signal is active) and the word “Danger” will flash on the appropriate display screen.
Helmet Module - Audio

- The Smart Helmet will also be displayed with a low power audio speaker. This speaker will alert the rider when there is an oncoming vehicle at the “Danger” level.
- Since the speaker will be mounted inside the helmet and will be so close to the rider, an audio amplifier is not needed.
Helmet Module - Wireless

- Also uses Bluetooth Low-Energy HM-10 Module (same as bike endpoint)
  - Communication via UART serial
- Set to Slave in the Master-Slave relationship
  - Receiving only (not required)
    - Smart packet-loss detection in software
    - Can dictate the receiving rate
  - Searches for host on boot
    - Less energy use compared to Bike
    - Limited by battery power
Helmet Module - Wireless

1. Byte received
2. Is byte a header? no
   - Currently receiving packet? yes
   - Discard byte
   - Is packet complete? yes
   - Make packet available
   - Save byte to buffer
3. Is byte a header? yes
   - Currently receiving packet? no
   - Start receiving fixed length packet
Helmet Module - Power Block Diagram
Helmet Module - Power

- Heads-Up Display Module Powered by Rechargeable Battery
  - Charged using USB and Solar Power
Helmet Module - MCU Block Diagram

- Wired Charging
  - USB Port
  - Rechargeable Battery
  - Solar Panels

- Wireless Receiver
  - Graphics/Audio Processor
    - Heads Up Display (HUD)
    - Alert Speaker

Helmet Mounted Module

- Microcontrollers
- Power
- Peripherals
Helmet Module - MCU

- Start
- Initialize components
- Is Bluetooth connected?
  - Yes: Update HUD display
  - No: Has transmission received?
    - Yes: Interpret transmission
    - No: Continue

# Project budget

<table>
<thead>
<tr>
<th>Item</th>
<th>Cost</th>
<th>Item</th>
<th>Cost</th>
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</thead>
<tbody>
<tr>
<td>Proximity Sensors</td>
<td>$240</td>
<td>Solar Panel</td>
<td>$10</td>
</tr>
<tr>
<td>Wireless</td>
<td>$30</td>
<td>Battery</td>
<td>$5</td>
</tr>
<tr>
<td>Helmet Display</td>
<td>$20</td>
<td>Helmet</td>
<td>$25</td>
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<tr>
<td>Voltage Regulators</td>
<td>$10</td>
<td>PCBs</td>
<td>$40</td>
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<tr>
<td>Battery Charger</td>
<td>$5</td>
<td>Misc</td>
<td>$50</td>
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<tr>
<td></td>
<td></td>
<td><strong>Total</strong></td>
<td><strong>$435</strong></td>
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</tbody>
</table>
Financing

- No external sponsors or funding
  - Split evenly four ways
  - Personally funded
- Limited budget
  - Encouraged cost effective design
  - Minimalistic design
- No sponsor oversight
  - Freedom to expand on ideas
  - Avoid politics
  - No managerial critique (good and bad)
## Progress overview

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Completion</th>
</tr>
</thead>
<tbody>
<tr>
<td>Build Prototype</td>
<td>100%</td>
</tr>
<tr>
<td>Test Prototype</td>
<td>100%</td>
</tr>
<tr>
<td>Redesign (If applicable)</td>
<td>2nd Revision</td>
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<tr>
<td>Finalize Prototype</td>
<td>95%</td>
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<tr>
<td>Final Presentation</td>
<td>In Progress</td>
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## Division of Labor

<table>
<thead>
<tr>
<th></th>
<th>MCU</th>
<th>Proximity Sensors</th>
<th>Power</th>
<th>Wireless Communication</th>
<th>Peripherals</th>
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<tbody>
<tr>
<td>Julian</td>
<td>P</td>
<td></td>
<td></td>
<td>S</td>
<td>P</td>
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<tr>
<td>Jorge</td>
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<td>Jeremy</td>
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<td>Blake</td>
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*Primary (P)*
*Secondary (S)*
Questions